

Design And Near-Field Measurement Performance Evaluation Of The SeaWinds Dual-Beam Reflector Antenna

Z. Hussein,* “2 Y. Rahmat-Samii,^{2,1} and K. Kellogg’

¹Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109

²University of California Los Angeles
Department of Electrical Engineering
Los Angeles, CA 90095-1594

INTRODUCTION: This paper presents the design and performance evaluation of a lightweight, composite material, elliptical-aperture, parabolic-reflector antenna. The performance characterization is obtained using the cylindrical near-field measurement facility at JPL [1] as shown in Figure 1. The reflector has been designed and calibrated for the SeaWinds spaceborne scatterometer instrument. The instrument operates at Ku-band and is designed to accurately measure wind speed and direction over Earth’s ocean surface. The SeaWinds antenna design requires two linearly polarized independent beams pointed at 40° and 46° from nadir as shown in Figure 2a. The inner beam, pointed at 40° from nadir, is horizontally polarized with 1.6° X 1.8° required beamwidths in the elevation and azimuth planes, respectively. The outer beam, pointed at 46° from nadir, is vertically polarized with 1.4° X 1.7° required beamwidths. Noteworthy, the reflector boresight axis is pointed at 43° from nadir. Both beams are required to have the first sidelobe level below -15 dB relative to the peak of the beam.

The antenna was required to have a fundamental structural resonant frequency of greater than 94 Hz. To meet this requirement, it was necessary to design the struts and feed support plate size larger than nominal optimal dimensions. As expected, the increased feed-plate aperture blockage and the interaction of the feed horns with the plate resulted in higher sidelobe levels, lower antenna gain, and altered the antenna beamwidths. Careful experimental and theoretical design considerations have been found to be necessary in order to optimize the antenna design.

DESIGN IMPROVEMENTS: The original design for the reflector antenna (without blockage effect) was based on a physical optics (PO) performance model with a $\cos^4\theta$ feed pattern. This model produced a minimum of 4 dB first sidelobe level margin, the required antenna beamwidths, pointing, and gain for both beam. The antenna configuration consists of an elliptical-aperture parabolic reflector with two offset feeds. The implementation of the antenna design with a large feed support plate that met the stiffness requirement showed a high sidelobe level exceeding the allocated margin. Combinations of the incorporation of absorbing material coated on the feed support plate, the extension of the feed-horn length (for the inner beam), and the addition of a choke around the outer beam feed horn, reduced the interaction between the feed horns and the support plate. Consequently, simultaneous improvements in the antenna gain,

sidelobe level, and antenna beamwidths were obtained. Figure 2b shows the antenna/feed configuration.

PERFORMANCE EVALUATION: RF pre- and postvibration test of the SeaWinds antenna were performed. The tests were aimed at characterizing the antenna RF performance and determining whether the previbration RF performance was retained. Tables 1 and 2 describe the postvibration performance parameters obtained from cylindrical near-field measurement for V-pol and H-pol, respectively, and intercomparison with the previbration test results. As can be seen, the relative change of antenna gain is 0.05 dB. The relative change of antenna beamwidth in the elevation and azimuth planes is within 0.01 degrees. Also, it was noted that antenna pointing in elevation remained the same. Antenna pointing in the azimuth plane varies by 0.1 degrees, and this is due to the mechanical positioner start and stop. Noteworthy, these small changes fall within the measurement uncertainties. Figure 3 shows comparison between the pre- and postvibration test of the antenna principal plane radiation patterns for both the horizontal and vertical polarization, respectively. As can be seen from these figures, the antenna patterns have sidelobe levels below -15 dB and demonstrate excellent repeatability.

Table 1. V-pol antenna performance parameters for pre- and postvibration test

SeaWinds Antenna (V-POL)	Gain (dB)	X-M* (dB)	Beamwidth El (degrees)	Beamwidth Az (degrees)	Pointing El (degrees)	Pointing Az (degrees)
Requirement	>36.5	< -20	1.4 +/- .1	1.7 +/- .1	46 +/- .1	-----
Postvibration test	40.91	-25.63	1.35	1.69	46.08	-0.05
Previbration test	40.86	-25.56	1.34	1.70	46.08	+0.05
Difference	0.05	0.07	0.01	0.01	0.00	0.10

Table 2. H-pol antenna performance parameters for pre- and postvibration test

SeaWinds Antenna (H-POL)	Gain (dB)	X-Pol* (dB)	Beamwidth El (degrees)	Beamwidth Az (degrees)	Pointing El (degrees)	Pointing Az (degrees)
Requirement	>39.2	< -20	1.6 +/- .1	1.8 +/- 0.1	40 +/- 0.1	-----
Postvibration test	39.27	-26.97	1.66	1.76	40.01	0.00
Previbration test	39.22	-26.54	1.66	1.76	40.02	+0.10
Difference	0.05	0.42	0.0	0.0	0.01	0.1

* relative to the peak of the beam

ACKNOWLEDGMENT: This work was carried at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. The authors thank C. Chandler and W. Faust for their creative suggestions, and R. Thomas for his assistance in the measurement.

REFERENCE: [1] Z. Hussein and Y. Rahmat-Samii, "On The Accurate Calibration of The SeaWinds Radar Antenna: A Cylindrical Near-Field Measurement Approach," 1996 International Geoscience and Remote Sensing Symposium, 96' IGARSS, Digest, Lincoln, Nebraska, May 1996.

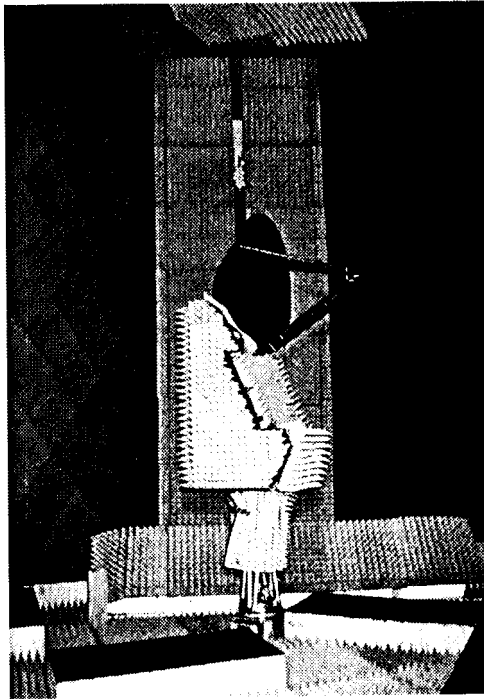
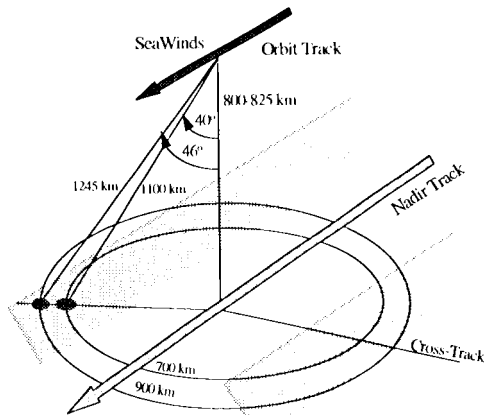
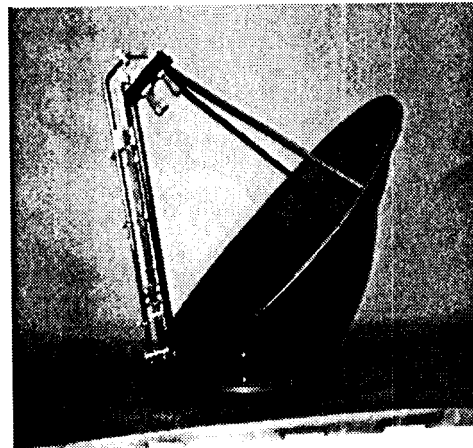


Figure 1. SeaWinds antenna mounted in the cylindrical near-field measurement facility at JPL



(a)



(b)

Figure 2. (a) SeaWinds conical-scan spot-beam illumination. (b) 1.07 m x 0.96 m Ku-band SeaWinds dual-feed reflector antenna. The reflector shell, waveguides, and feeds are made of lightweight composite material (total weight is 6.40 Kg.)

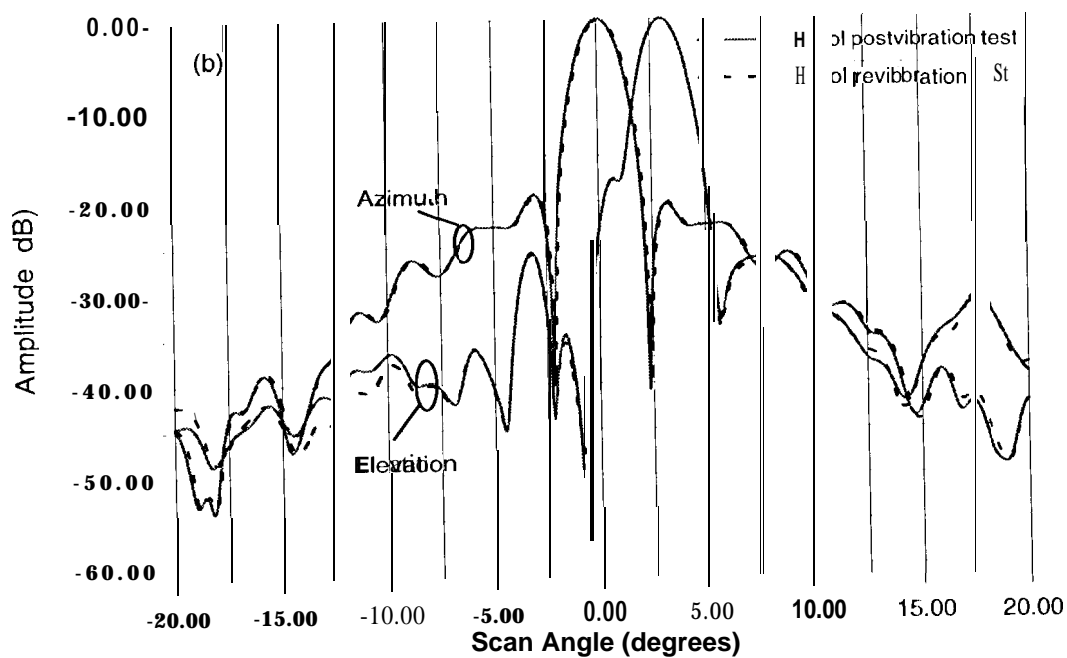
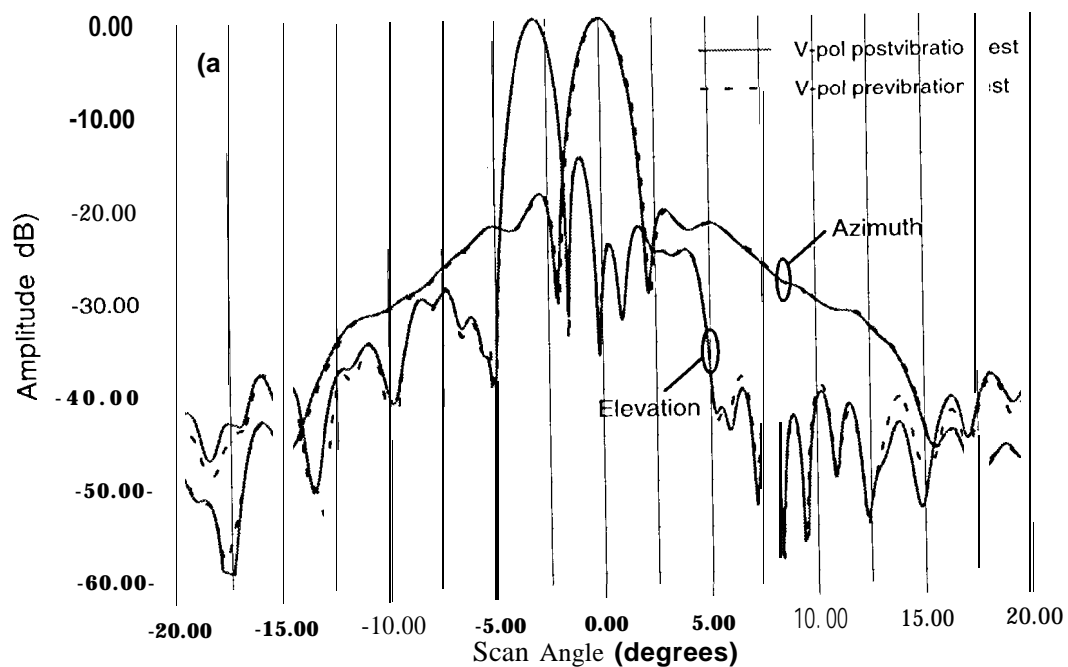


Figure 3. Comparison of far-field radiation patterns (elevation and azimuth planes) of the SeaWinds flight antenna taken before and after vibration test. The patterns are obtained from cylindrical near-field measurements taken at a radial distance of 101.22 cm: (a) V-pol (outer beam), (b) H-pol (inner beam). Note that the azimuth cuts are taken through the beam peaks.